

the cost of the building. The second affects its stability and must be solved definitely before the building of a house in this way can be accomplished.

On the whole the idea is one of rather revolutionary type in engineering construction, but judging from what Mr. Edison has already accomplished toward

the solving of the practical difficulties which have arisen, it is likely that he will in the end be successful in building a house in the way he has planned.

THE EYE OF MATHEMATICS.*

WHAT THE TRAINED IMAGINATION CAN DO.

BY PROF. CASSIUS J. KEYSER.

OBSERVATION by the inner eye of the things of thought is observation, not less genuine, not less difficult, not less rich in its objects and disciplinary value, than is sensuous observation of the things of sense. But this is not all, nor nearly all. Indeed for direct beholding, for immediate discerning, of the things of mathematics there is none other light but one, namely, psychic illumination, but mediately and indirectly they are often revealed or at all events hinted by their sensuous counterparts, by indications within the radiance of day, and it is a great mistake to suppose that the mathetic spirit elects as its agents those who, having eyes, yet see not the things that disclose themselves in solar light. To facilitate eyeless observation of his sense-transcending world, the mathematician invokes the aid of physical diagrams and physical symbols in endless variety and combination; the logos is thus drawn into a kind of diagrammatic and symbolical incarnation, gets itself externalized, made flesh, so to speak; and it is by attentive physical observation of this embodiment, by scrutinizing the physical frame and make-up of his diagrams, equations and formulæ, by experimental substitutions in, and transformations of, them, by noting what emerges as essential and what as accidental, the things that vanish and those that do not, the things that vary and the things that abide unchanged, as the transformations proceed and trains of algebraic evolution unfold themselves to view—it is thus, by the laboratory method, by trial and by watching, that often the mathematician gains his best insight into the constitution of the invisible world thus depicted by visible symbols. Indeed the importance to the mathematician of such sensuous observation cannot be overrated. It is not merely that the craving to see has led to the construction of the manifold models, ingenious and noble, of Schilling and others, illustrating important parts of Higher Geometry, Analysis Situs, Function Theory, and other doctrines, but the annals of the science are illustrious with achievements made possible by facts first noted by the physical eye. To take a simple example from ancient days, it was by observation of the fact that the square of certain numbers are each the sum of two other squares, the detection and collection of these numbers by the method of trial, observation of the fact that apparently all and only the numbers of such triplets are measures of the sides of right triangles—it was thus, by observation and experiment, by the method of incomplete induction, common to the experimental sciences, that the Pythagorean theorem, now familiar throughout the world, was discovered. It was by Leibnitz's observation of the definitely lawful manner in which the coefficients of a system of equations enter their solution that the suggestion came of a notion on the basis of which there has grown up in our time an imposing theory, an algebra built up on algebra—the colossal doctrine of Determinants. It was the observation, the detection by the eye of Lagrange and Boole and Eisenstein, of the fact that linear transformation of certain algebraic expressions leaves certain functions of their coefficients absolutely undisturbed in form, unaltered in frame of constitution, that gave rise to the concept, and therewith to the morphological doctrine, of Invariants, a theory filling the heavens like a light-bearing ether, penetrating all the branches of geometry and analysis, revealing everywhere abiding configurations in the midst of change, everywhere disclosing the eternal reign of the law of form. It was in order to render evident to sensuous observation and to keep constantly before the physical eye the pervasive symmetry of mathematical thought that Hesse in the employment of homogeneous co-ordinates set the example, since then generally followed, of replacing a variety of different letters by repetitions of a single one distinguished by indices or subscripts—a practice yet further justified on grounds both of physical and of intellectual economy. It was by sensuous observation that Clerk Maxwell, in the beginning of his wondrous career, detected a lack of symmetry in the then recognized equations of electrodynamics, and by that observed fact together with a discriminating sense of the scientific significance of esthetic intimations, he was led to remove the seeming blemish by the addition of a term, antedating

experimental justification of his daring deed by twenty years; an example of prescience not surpassed by that of Adams and Leverrier who, while engaged in the study of planetary disturbance, each of them about the same time and independently of the other, felt the then unknown Neptune "trembling on the delicate thread of their analysis" and correctly informed the astronomer where to point his telescope in order to behold the planet. One might go on to cite the theorem of Sturm in Equation Theory, the "Diophantine Theorems of Fermat" in the Theory of Numbers, the Jacobian "doctrine of double periodicity" in Function Theory, Legendre's law of reciprocity, Sylvester's reduction of Euler's problem of the Virgins to the form of a question in Simple Partitions, and so on and on, thus continuing indefinitely the story of the great rôle of observation, experiment and incomplete induction, in mathematical discovery. Indeed it is no wonder that even Gauss, *facile princeps mathematicorum*, even though he dwelt aloft in the privacy of a genius above the needs and ways of other minds, yet pronounced mathematics "a science of the eye."

Indeed the time is at hand when at least the academic mind should discharge its traditional fallacies regarding the nature of mathematics and thus in a measure promote the emancipation of criticism from inherited delusions respecting the kind of activity in which the life of the science consists. Mathematics is no more the art of reckoning and computation than architecture is the art of making bricks or hewing wood, no more than painting is the art of mixing colors on a palette, no more than the science of geology is the art of breaking rocks, or the science of anatomy the art of butchering.

Did not Babbage or somebody invent an adding machine? And does it not follow, say Holmes and Schopenhauer, that mathematical thought is merely a mechanical process? Strange how such trash is occasionally found in the critical offering of thoughtful men and thus acquires circulation as golden coin of wisdom. It would not be sillier to argue that, because Stanley Jevons constructed a machine for producing certain forms of logical inference, therefore all thought, even that of a philosopher like Schopenhauer or that of a poet like Holmes, is merely a thing of pulleys and levers and screws, or that the pianola serves to prove that a symphony by Beethoven or a drama by Wagner is reducible to a trick of mechanics.

LOSSES RESULTING FROM BAD WEATHER.

Of course every one is interested in the weather, but few think how much effect it has on trade. In this connection the Dresdner Anzeiger sums up, apparently from English sources, some figures concerning the cost of bad weather to those engaged in the different branches of trade. When it rains, nearly all tradesmen complain of bad business, except the cigar dealers; the latter, however, rub their hands with delight. The desire to make a bad day more endurable by a good cigar increases the takings of the cigar dealer by 15 per cent. That public-house keepers in the city have no cause for complaint, every one knows. Whoever has anything to do in the street supplies himself with umbrella and rain coat, and these cost money. In nearly all other shops the proprietors wait unavailingly for customers. Ladies especially have no great desire to shop in the rain. That means a considerable loss of trade; it has been estimated that the shops in the West End of London lose by a single rainy day \$500,000.

Some kinds of merchandise are especially sensitive to the influence of the weather. Mutton and pork, for instance, are spoiled by very strong electric discharges; so that many a butcher will lose \$50 to \$75 by a thunderstorm.

A real London fog is much more expensive, by reason of its impenetrable darkness. For gas alone, London expends per day, when there is a fog, \$7,500 more than usual. The apothecaries are pleased by such weather, for the reason that it causes a number of diseases, so that their income is doubled. The underground railways also have their income increased by rain and fog. Naturally, it is much more pleasant to be protected from wind and wet than to sit on top of an omnibus and get soaked through.

So Nature causes considerable expenditure for man. She herself is a spendthrift, as in a storm she wastes giant forces. The storm that destroyed Galveston could have furnished the power given by all the steam engines of the world for years. A single thunderstorm would suffice to drive all the dynamos in existence, and the average value of a flash of lightning has been calculated as about \$1,250.

OZONE IN A GERMAN THEATER.

THOUGH the sterilizing effects of ozone have been known for some time, no successful attempts seem to have been so far made to utilize these effects on a practical scale, especially for the purifying of the air.

Ventilators will supply to crowded rooms continual amounts of more or less pure outside air; but this air usually requires heating, which greatly increases the cost of operation. These drawbacks are obviated by using ozone to produce a pure atmosphere without any draft or change in temperature. Interesting experiments on this use of ozone have been made in the course of the past year at the Royal Theater, Stuttgart, the vestibule, foyers, cloakrooms, and supers' hall being aerated effectively with an ozone apparatus. The success of these experiments, made on a small scale, led to a full installation of pipes connected to the ozone apparatus being carried to each point in the theater where ozone was needed. The supply was accurately controlled, and the whole auditorium supplied in a few minutes with sufficient ozone to destroy any traces of bad air throughout the building.

The cost of operation of this process was found to be extremely low, while any draft or increase in temperature was done away with. Similar success has attended experiments recently made in telephone exchanges, hotels, cellars, and assembly halls.

The apparatus, according to a recent issue of the *Gesundheitsingenieur*, comprises a small electromotor actuating an air blower, while another motor is converting continuous current into alternating current, to which the tension required for adequate working is imparted by a transformer. The alternating current enters the ozone battery, where it traverses the field of electric discharge. The air coming from the blower being thrown through the field of discharge undergoes the conversion of its oxygen into ozone. This apparatus should contribute to a solution of the ventilating problem, and would seem to be a new departure from the hygienic point of view.

BRAZILIAN COPAL GUM.

FOR the benefit of American inquirers who are interested in "jatoba" or "jatahy," commonly known as Brazilian copal gum, Consul-General George E. Anderson, writing from Rio de Janeiro, says that it seems safe to say that considerable business in this product can be done if there is sufficient demand for it to warrant gathering it on a large scale. He adds:

"Last year the exports of the product from Brazil amounted, at a valuation of about 67 cents a pound, to a total of about \$9,000. The quality of the gum, as suitable for use in the manufacture of varnish and for some medicinal purposes, is said to be very good. There are large supplies of the product to be had in Minas Geraes in pockets in the ground, being thus collected by the burning of forests containing trees bearing the gum. The gum being thus melted forms pools, which harden and preserve the product. The trade in the gum so far has been so small that there has been no systematic effort to work these sources of supply.

The increase in suburban railway traffic at Rio de Janeiro has been so great as to call for some solution of the problem of providing adequate facilities for the large population which depends for transportation upon these trains. The number of passengers carried in the suburban trains increased from 12,600,000 in 1901 to 19,250,000 in 1906, an increase of about 52 per cent. It has been proposed that the suburban lines be electrified, and plans are now being made to that end. The mileage will probably be about 20 miles. The plan specifies that trains are to run on a schedule providing a three-minute service, or twenty trains per hour, accommodating 40,000,000 passengers per year.

* Abstract from a lecture on mathematics, delivered at Columbia University, in the series on Science, Philosophy and Art.